Appendix A

Overview of the Hydraulic Capacity Analysis Used to Identify Capacity Needs

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1.0 Hydraulic Capacity Evaluation for the Separated System

Existing conveyance facility capacities in the separated system of King County were evaluated for the purpose of accommodating the 20-yr peak flow through the 2050 planning horizon[1]. Conveyance facilities considered in the analysis included gravity feed pipes, forcemains, inverted siphons, and pump stations. Overflow facilities and outfalls were not evaluated.

1.1 Assessment of Flow Demand

A representation of the separated conveyance system was mapped to a spreadsheet, where conveyance facility capacities were compared against projected 20-yr peak flows by decade. Existing winter conveyance routes were assumed for year 2000, and were revised to convey proposed flow to Brightwater STP in 2010 and beyond.

Peak 20-year flows for each modeling basin were derived by simulating a 60-year rainfall record using the calibrated hydrologic model MOUSE RDII[2] to generate a 60-year time series hydrograph. The peak flow events from all basins were then routed through the conveyance system using the hydraulic model MOUSEHD. The peak 20-year flows at all points in the King County system were estimated from this long-term simulation.

Within the spreadsheet representation of the separated conveyance system, the accumulation of model basin peak flows were reduced by attenuation to account for the following:

1) travel time along trunks
2) non-coincidence of peaks arriving from adjoining trunks
3) temporal variation of the 20-yr flow event occurring within the 60yr rainfall record (i.e., not all basins' 20-year peak flows were caused by the same storm)

Appropriate attenuation factors were derived to adjust the cumulative model basin 20-yr peak flows in 2000 to match the 20-year peak flows from MOUSEHD. These attenuation factors were retained to attenuate flows in subsequent decades.

1.2 Assessment of Capacity

Capacity for gravity feed pipes was assessed by grouping adjacent pipes into hydraulically representative pipe reaches. These consisted of trunklines of contiguous pipes of a common diameter located between major connections. The use of pipe reaches to assess capacity means that local surcharging experienced in individual pipes would be allowed as long as the overall pipe reach is not surcharged.

Pipe reach capacity was calculated from Manning's equation for pipes flowing full under steady, uniform flow conditions. For use in this equation, a representative gradient was derived as the vertical difference between the upstream and downstream inverts of the pipe reach divided by the sum of the individual pipe lengths in the pipe reach. Forcemain capacities were calculated as the product of the cross sectional area for a pipe flowing full and a maximum velocity of 8 fps. Specifications for peak pump station capacities were documented in WTD publication "Offsite Facilities" [3].

1.3 Determination of Exceedance

Regardless of the methodology used to assess capacity, the determination of exceedance for conveyance facilities remained consistent. Available capacity was compared to projected 20-yr peak flow demand by decade. For facilities determined to be exceeded, the year when flow demand exceeded capacity was determined by linearly interpolating between projected flows on the decades (see Figure 1).

If the saturation flow at 2050 exceeded capacity by <5%, then no new facility would be required. It was assumed that 1) the <5% exceedance would be addressed by limited surcharging, and 2) the pipe could accommodate >15-yr peak flows without surcharging (see Figure 2).

1.4 Supplemental Modeling for Exceeded Pipe Reaches

Spreadsheet analysis was appropriate for normal gravity feed pipe reaches, where capacity was determined from friction losses. However, more sophisticated methods were required to assess the capacity of pipe reaches where local head losses at pipe bends, expansions and contractions, and parallel pipe bifurcations and convergences were significant, as well as for hydraulically complex facilities such as inverted siphons, low-head crossings and drop structures.

Supplemental MOUSEHD modeling will assess the extent of surcharging in pipe reaches to prioritize, or even eliminate, conveyance system improvements identified in the Regional Needs Assessment Report (see Figures 3 and 4).

2.0 Assessment of the Combined System

Conveyance facilities in the combined system of King County must further accommodate stormwater flows in addition to wastewater flows. In contrast to the separated system, conveyance facilities in the combined system were evaluated towards limiting discharges at Combined Sewer Overflow points (CSO's) to one event per year on average by 2030[5]. Their evaluation consisted of flow regulation using control systems, storage, and treatment options.

2.1 Modeling for Combined System Overflows

Present numerical modeling capabilities used to predict and regulate combined system flows have evolved over time. Flows from watershed basins to upper reach pipe systems were predicted with the calibrated model Runoff/Transport. Lower pipe reach flows and control system operations were simulated using the model UNSTDY. Both models were customized to support sophisticated controls and features not available in commercial models.

To evaluate proposed control strategies or modifications, both models were run in tandem to simulate several years of operation. Several runs and adjustments were typically required to meet control strategy goals or assess system modifications.

[1] The 20-yr Peak Flow was adopted as the design standard from the 1999 RWSP
[2] Regional Needs Assessment Report, 3/1/05, Appendix A4
[3] WTD document "Offsite Facilities", June, 1999
[4] Regional Needs Assessment Report, 3/1/05, Appendix A1
[5] goal adopted from Regional Wastewater Services Plan, 1999

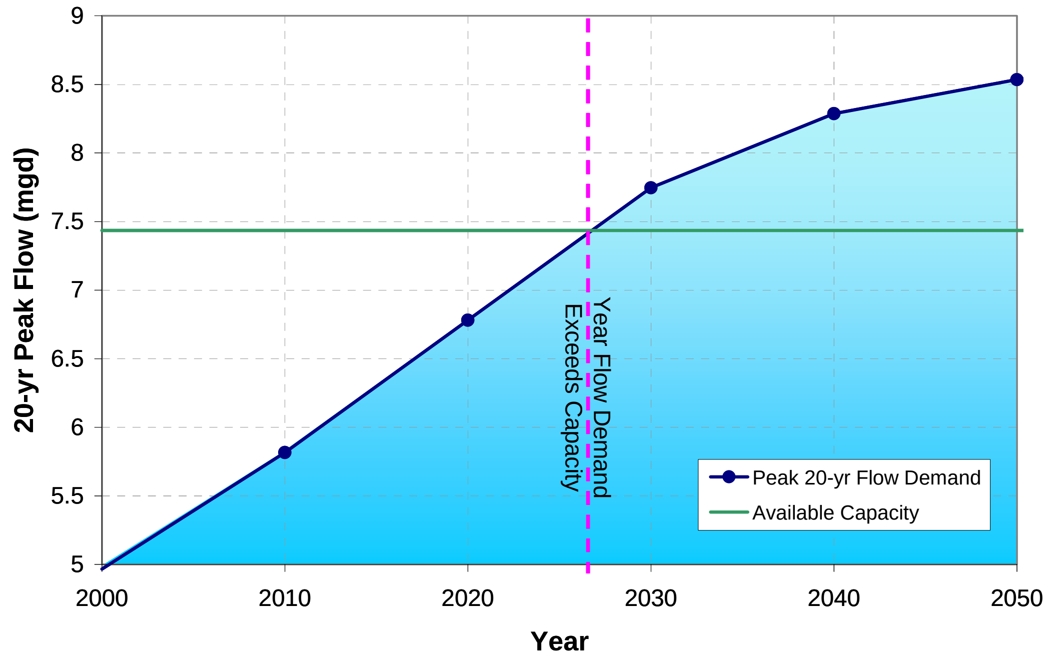

Figure 1. Determination of Exceedance and Year Exceeded

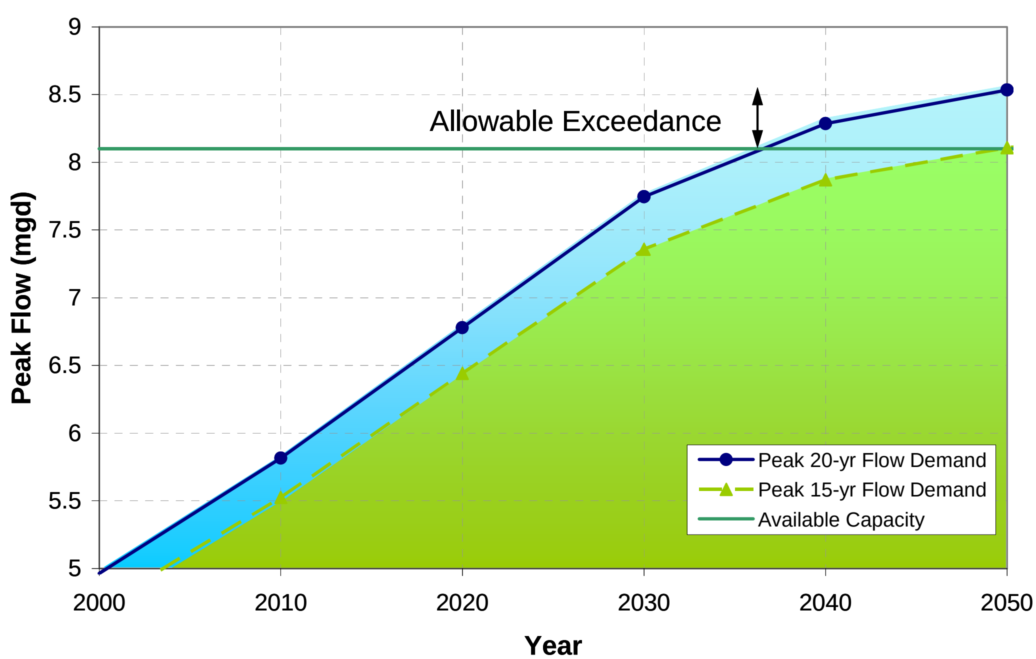

Figure 2. Allowable Exceedance at 2050 Saturation Flow Demand

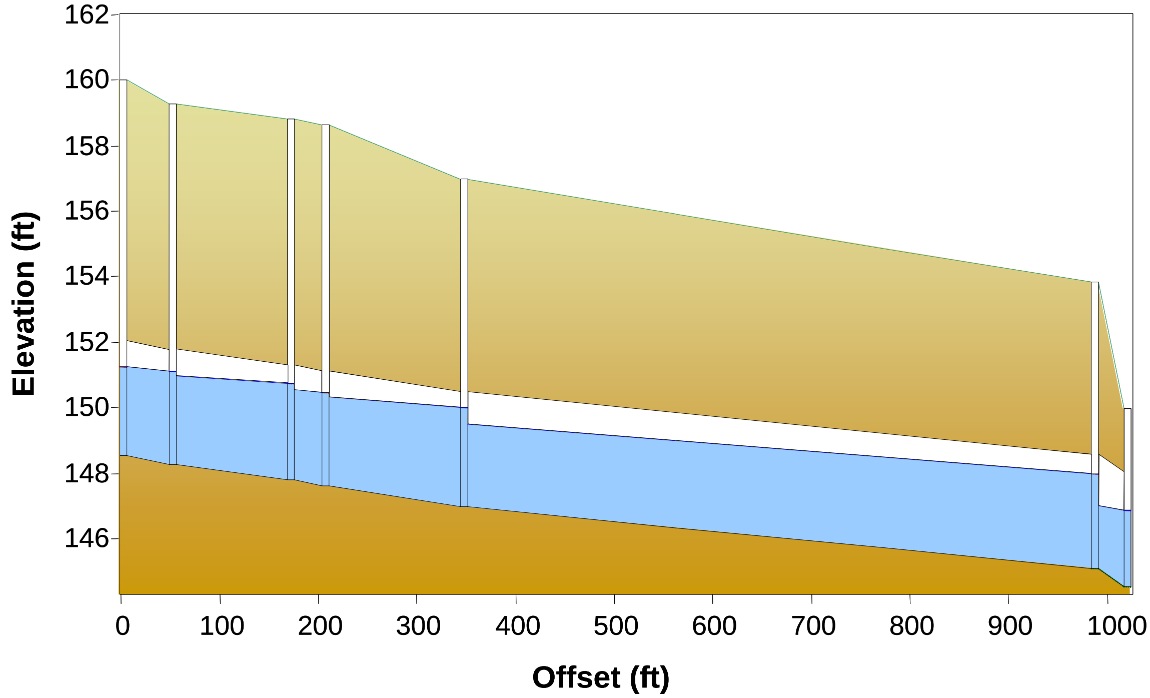

Figure 3. MOUSE profile without surcharging

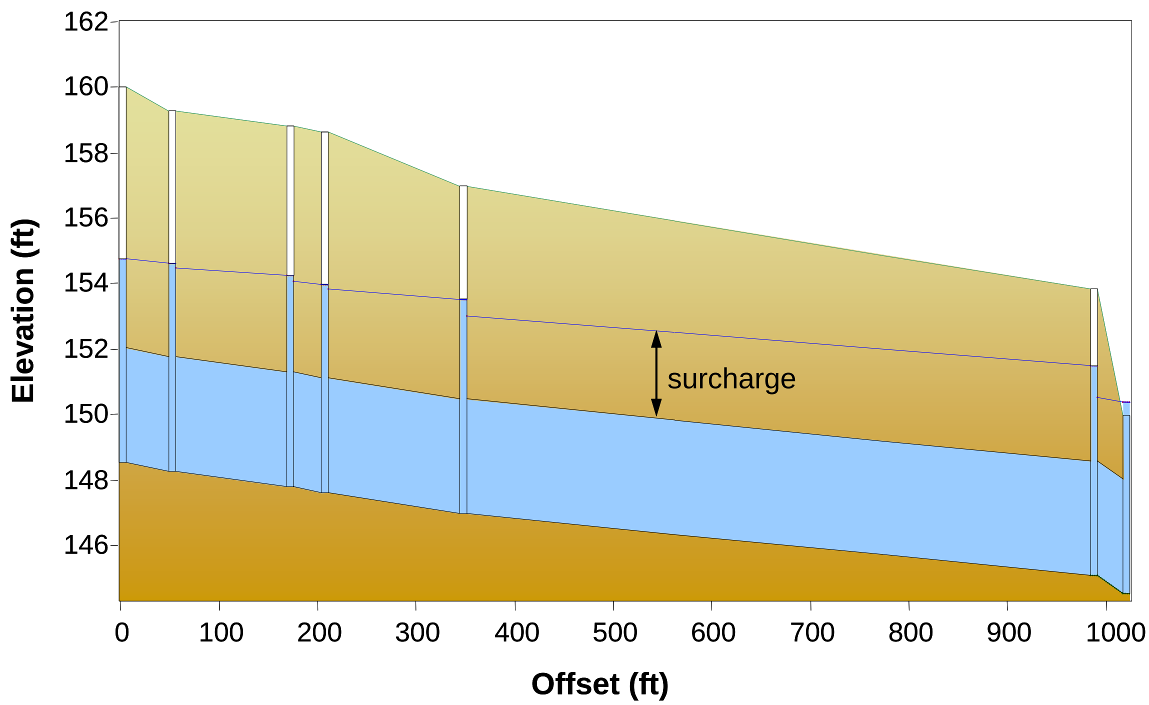

Figure 4. MOUSE profile with surcharging